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THE QUALITY OF RESEARCH¹

C. H. BENJAMIN

On that form which sets forth the qualifications of candidates for membership in this society, the most prominent items are those which show the present activity in research and the published evidence of past industry. A candidate may have an unblemished record as a scholar and as a man, but if he lack *this*, he is nothing. What is this so important qualification and why is it thus emphasized? The question can only be answered by tracing the growth of the spirit of investigation and measuring its influence on the history and the welfare of the race.

Man is born a curious animal, and, like the Lady of the Aroostook, always "wants to know." The most insistent cry of infancy and youth is, "Why, mother, why?" As a race and as individuals we are born on the borders of an undiscovered country, and with our first steps and our first thoughts we begin a tour of investigation. The elementary forces of nature—air, water, fire, sun, moon, stars, morning and night, seedtime and harvest—furnish ever new problems, new opportunities for research.

There is not quite the romance in it that there once was, when all the world was new and imagination ran loose without the bridle of knowledge. Geography, even, was romance in those earlier days of Eldorados and Fountains of Youth. Now, just a few patches of ice to be explored, a few scraps of wilderness in Asia or Africa—and geography becomes merely a fact.

The day of romance in scientific exploration has not yet passed. We match the seven-league boots with electricity and motor cars. The aeroplane soars and glides as wonderfully as the magic carpet. The wonders of crystal gazing and of second sight are matched by those shown in the magic lens of the biologist and the astronomer. We are really getting blasé and incapable of appreciating new sensations; one revolutionary discovery follows another with such rapidity that we are losing all sense of relation or proportion.

We can not all hope to be great discoverers; it is only to the few that the big diamonds come, the heavy nuggets. But we will dig just the same, dig hard and long, knowing that every stroke

¹An address delivered by Dean Benjamin before the Purdue Chapter of Sigma Xi, May 20, 1916.

counts. Most research nowadays is just digging, and hard, slow work at that. "An infinite capacity for taking pains"—Carlyle's definition, although a very poor one for genius, fits this case exactly. In no field of endeavor are the stones all turned; in no lines of investigation are the facts and data all revealed. The most that we have, and all that we are, has come from the work of investigators searching for truth, some of them great and famous, some of them humble and unknown, but each doing his part in adding to the sum of human knowledge and the wealth of human experience.

How shall we do *our* part? It is the first duty of an investigator to know what has been done—research must usually begin in the library. Of what avail to conduct a carefully planned series of experiments, to find later that the work has been earlier and perhaps better done by another? "Zeal without knowledge is an evil though it be zeal unto good." If we are to add to the structure, we must build on what is already in place. Knowing then, as patent experts say, "the state of the art," we may add our quota and make it an integral part of the structure.

We owe it to ourselves and to others to do the part well, be it great or small. If we make but one brick, let it be sound and true and laid conscientiously, that no after builder may tear it out and reject it. Not how much, but how well.

And let it be entirely clear to us why we are doing this. No investigation is germane and true unless it has for its object the general benefit. Are you working for commercial gain? It may be successful, but it is not scientific. Agassiz said, "I have no time to make money." Are you studying to increase your personal prestige, your scientific reputation? You deserve to fail, as you probably will. If you are a true member of Sigma Xi, your motives are not these. In your chosen field you find many details which are wanting, some apparent facts not yet understood. Stimulated by a commendable curiosity and by an earnest desire to do your share, you begin an investigation: first, of what has been done; second, of what can be done. You reason, you experiment. The results may after all be negative. Close up the cul-de-sac and save the next traveler a like experience. Even scrap heaps may be evidence of progress. Your results may be positive but meager. Never mind, you have the experience which is usually worth all the trouble.

But above all be sure, be accurate. Never guess, never tolerate a doubtful experiment, an unreliable observation. Test every detail, every joint in the structure, or some time the whole will come tumbling about your ears to your great mental discomfort and perhaps to the irreparable damage of your reputation. Be as conscientious with yourself and your work as though every item were published for all to see.

Published—aye there's the rub—why publish, and when and where and how? "Fools rush in where angels fear to tread" is an epigram especially designed for those who publish prematurely. "Am I publishing for my own benefit or for that of the scientific world?" If for the latter, then the solution is simple. When the data which I have collected, the facts which I have proved, are sufficient in number or importance to be of value to others in my profession, it is my duty as well as privilege to publish them. It is further my duty to use that medium of publication which shall most effectively bring these facts to the attention of those who will make the best use of them. No consideration of a cent a word in the nearest technical journal should weigh against the dignity and scientific worth of the transactions of a national or international society.

Neither must I wait until I have, in my own estimation, exhausted the subject, pumped the well dry. That day may not come, and meanwhile facts which others have a right to know are locked up in my treasure chest. Put the medium in circulation; you will usually get compound interest on it. You and I have no more right to hoard information than to hoard money. If what you have is good coin and rings true, that is enough, be it a penny or be it a pound. If it is counterfeit, you should know it and you are responsible. If in doubt, pray for more light and hold on.

Nothing is trivial which is true and which helps make up the total. It may be your lot to furnish the *and* or *but* which ties together whole sentences of discovery—to find the pin on which turn momentous trains of research. And so, building on what has gone before, testing your hypotheses gingerly (for hypotheses are but the false work, the centering of your arch), you may so build that your bridge will stand alone and span the chasm never bridged before. But again, mind the details, the little things without which

your work is but a loose aggregation of unrelated parts and when some rival attacks your hypotheses, the laborious whole comes crashing to the ground carrying your reputation with it, an irretrievable wreck.

Our key:

- First, Knowledge of what is;
- Second, Vision of what may be;
- Third, Patience in toil;
- Fourth, Accuracy in results.

These are the four corners of the key of Sigma Xi, which will unlock the secrets of nature.